GRINDING IN LEAD-ZINC CONCENTRATOR SASA – CHOICE BETWEEN DIFFERENT GRINDING MEDIA

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ABSTRACT

In this paper will be present result obtained from investigation in the grinding circuit of the lead-zinc concentrator Sasa,using differen grindng media:

- *Litzkhun-Niederwipper Forged Steel grinding balls;*
- *GSI LUCCHINI Moly-Cop Forged Steel grinding balls;*
- *Cast steel grinding balls from Ukraina and Bulgaria;*

In the same time will be shown comparation between obtained parameters using different grinding balls specially:

- *Capacity of the grinding mill;*
- *Particle size;*
- *Specific Energy;*

1. INTRODUCTION

One of the major objects of comminution is the liberation, or release, of the valuable minerals from the associated gangue minerals at the coarsest possible particle size.. If such an aim is achieved, then not only is energy saved by the reduction of the amount of fines produced, but any subseqent separation stages become easier and cheaper to operate. If high-grade solid products are required, then good liberation is essential; however, for subsequent hydrometallurgical processes, such as leaching, it may also be necessary to expose the required mineral. In practice complete liberation is sedom achieved, even if the ore is ground down to the grain size of the desired mineral particles. It can be said that each paticle produced containing mineral also contains a portion of gangue; complete liberation has not been attained; the bulk of the major mineral – the gangue –has, however, been liberated from the minor mineral – the value.

The "degree of liberation2 refers to the percentage of the mineral occurring as free particles in the ore in relation to the total content. This can be high if thre ae weak bounderies between mineral and gangue particles, which is often thecase with ores composed mainly of rock-forming minerals, particularly sedimentary materials. New approaches to incrasing the degree of liberation involve directing the breaking stresses at the mineral crystal bounderies, so that the rock can be broken without breaking the mineral grains.

In practice, ores are ground to an optimum mesh of grind, determind by laboratory and pilot scale testwork, to roduce an economic degree of liberation. Grinding in a rod or ball mill is effected by point contact of balls and ore particles and, given time, any degree of fineness can be achieved. Grinding balls are usually made of forged or rolled high-carbon or alloy steel, or cast steel, and consumption varies between 0,1 to as much as 1 kg per tonne of ore depending on hardness of ore, fineness of grind and medium quality. Medium consumption can be a very high proportion, sometimes as much as 40%, of th total milling cost, so is an area that often warrants special attention. Good quality grinding media may be more expensive, but may be economic due to lower wear rates. Very hard media, however, may lead to lower grinding efficiencies due to slippage, and this also should be taken into account.

1.1 Determination of the surface characteristics

The equations for determination of the surface characteristics:

$$S_{ot} = \frac{S_k}{G} = \frac{S_k}{V_k \delta} = i \times \frac{1}{\delta} = \frac{6}{d_s} \times \frac{1}{\delta}$$

$$S_{ot} = \frac{6}{d_s} \times \frac{1}{2{,}65} = \frac{2{,}26}{d_s} \left(cm^2 \times gr^{-1} \right)$$

$$\frac{R_1}{100} + \frac{R_2}{100} + \ldots\ldots\ldots + \frac{R_n}{100} = 1 gram$$

$$S_{ot} = \frac{0{,}06}{\delta} \left(\frac{R_1}{d_{s1}} + \frac{R_2}{d_{s2}} + \ldots\ldots\ldots\ldots + \frac{R_n}{d_{sn}} \right)$$

$$S_{ot} = \frac{0{,}06}{\delta} \left(R_1 \times X_1 + R_2 \times X_2 + \ldots\ldots\ldots\ldots\ldots + R_n \times X_n \right) = \frac{0{,}06}{\delta} \sum_{i=1}^{n} R_i \times X_i$$

$$\Delta X_1 = X_2 - X_1 \ldots\ldots\ldots\ldots X_2 = X_1 + \Delta X_1$$

$$\Delta X_2 = X_3 - X_2 \ldots\ldots\ldots\ldots X_3 = X_1 + \Delta X_1 + \Delta X_2$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\Delta X_{n-1} = X_n - X_{n-1} \ldots\ldots\ldots X_n = X_1 + \Delta X_1 + \Delta X_2 + \ldots\ldots + \Delta X_{n-1}$$

The equation will be expressed as following:

$$\frac{0{,}06}{\delta} \left[X_1 \sum_{i=1}^{n} R_i + \sum_{j=1}^{n-1} \Delta X_j \times \sum_{i=j+1}^{n} R_i \right]$$

1.2 Experimental results

Table 1.Results of the sieve tests with surface characteristics-Feed in rod mill-I Phase

***Sieve size range* (μk)**	**X_i=1/d_{si}**	$\Delta X_j \left(sm^{-1} \right)$	$\sum_{i=1}^{n} R_i$	$\sum_{i=j+1}^{n} R_i$	$S_o \times \frac{\delta}{0{,}06}$
+ 295	28,2	-	36,5	-	1029,3
- 295 + 208	39,5	11,3	-	32,9	371,8
- 208 + 147	56,5	17,0	-	24,8	421,6
- 147 + 104	80,0	23,5	-	18,0	423,0
- 104 + 74	112,4	32,4	-	7,7	249,5
+ 74	63,5	84,2	-	-	2495,2

Table 4.Results of the sieve tests with surface characteristics- Feed in rod mill-II Phase

***Sieve size range* (μk)**	**$X_i=1/d_{si}$**	$\Delta X_j \left(sm^{-1}\right)$	$\sum_{i=1}^{n} R_i$	$\sum_{i=j+1}^{n} R_i$	$S_o \times \frac{\delta}{0,06}$
+ 295	28,2	–	37,5	–	1057,5
– 295 + 208	39,5	11,3	–	30,9	349,2
– 208 + 147	56,5	17,0	–	22,6	384,2
– 147 + 104	80,0	23,5	–	19,1	448,8
– 104 + 74	112,4	32,4	–	8,9	288,4
+ 74	63,5	84,2	–	–	2528,1

Table 7.Results of the sieve tests with surface characteristics- Feed in rod mill-I Phase

***Sieve size range* (μk)**	**$X_i=1/d_{si}$**	$\Delta X_j \left(sm^{-1}\right)$	$\sum_{i=1}^{n} R_i$	$\sum_{i=j+1}^{n} R_i$	$S_o \times \frac{\delta}{0,06}$
+ 295	28,2	–	36,7	–	1034,9
– 295 + 208	39,5	11,3	–	31,5	355,9
– 208 + 147	56,5	17,0	–	25,8	438,6
– 147 + 104	80,0	23,5	–	20,0	470,0
– 104 + 74	112,4	32,4	–	7,9	256,0
+ 74	63,5	84,2	–	–	2552,4

Table 10.Results of the sieve tests with surface characteristics- Feed in rod mill-II Phase

***Sieve size range* (μk)**	**$X_i=1/d_{si}$**	$\Delta X_j \left(sm^{-1}\right)$	$\sum_{i=1}^{n} R_i$	$\sum_{i=j+1}^{n} R_i$	$S_o \times \frac{\delta}{0,06}$
+ 295	28,2	–	36,2	–	1012.4
– 295 + 208	39,5	11,3	–	31,9	360,5
– 208 + 147	56,5	17,0	–	24,6	418,2
– 147 + 104	80,0	23,5	–	21,1	495,9
– 104 + 74	112,4	32,4	–	8,0	259,2
+ 74	63,5	84,2	–	–	2546,2

Table 13.Results of the sieve tests with surface characteristics- Feed in rod mill-I Phase

***Sieve size range* (μk)**	**$X_i=1/d_{si}$**	$\Delta X_j \left(sm^{-1}\right)$	$\sum_{i=1}^{n} R_i$	$\sum_{i=j+1}^{n} R_i$	$S_o \times \frac{\delta}{0,06}$
+ 295	28,2	–	35,9	–	1033,9
– 295 + 208	39,5	11,3	–	30,5	344,6
– 208 + 147	56,5	17,0	–	23,8	404,6
– 147 + 104	80,0	23,5	–	20,0	470,0
– 104 +	112,4	32,4	–	10,9	353,2

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+ 74	63,5	84,2	-	-	2606,3

Table 16.Results of the sieve tests with surface characteristics- Feed in rod mill-II Phase

***Sieve size range* (μk)**	**X_i=1/d_{si}**	$\Delta X_j\left(sm^{-1}\right)$	$\sum_{i=1}^{n} R_i$	$\sum_{i=j+1}^{n} R_i$	$S_o \times \frac{\delta}{0{,}06}$
+ 295	28,2	-	37,0	-	1043,4
- 295 + 208	39,5	11,3	-	33,2	375,2
- 208 + 147	56,5	17,0	-	25,6	435,2
- 147 + 104	80,0	23,5	-	18,0	423,0
- 104 + 74	112,4	32,4	-	9,7	314,3
+ 74	63,5	84,2	-	-	2591,1

Surface characteristics	$S_o \times \frac{\delta}{0{,}06}$ **(*sm²/gr*)**
Discharge from rod mill-I Phase	3235,6
Discharge from ball mill-I Phase – Cast steel	3966,8
Discharge from rod mill-II Phase	3350,6
Discharge from ball mill-II Phase – Cast steel	3879,6
Discharge from rod mill-I Phase	3306,7
Discharge from ball mill-I Phase – L&N forged	***4895,8***
Discharge from rod mill-II Phase	3268,8
Discharge from ball mill-II Phase – L&N forged	***5127,8***
Discharge from rod mill-I Phase	3287,1
Discharge from ball mill-I Phase – GSI Lucchini	4678,4
Discharge from rod mill-II Phase	3305,6
Discharge from ball mill-II Phase - GSI Lucchini	4756,4

1.3 Proposals for solutions

Bearing in mind that in mineral processing grinding is the final stage in "unlocking" and "liberation" of mineral grains, no doubt, there is need for the newly created surfaces to take place in highly favourable conditions in order to achieve good technological results such as production-hour capacity and efficiency of grinding.

By all means the predicted technological process should be maintained and performed in the best possible manner respecting, at the same time, the influences such as construction characteristics of grinding aggregates, the nature of grinding environment - grinding bodies, the character of ore crushed that is brought to be ground etc.

Bearing in mind the mentioned above, at the same time relying on our experiences gained so far in the field of grinding - classifying in the Flotation Plant of the Sasa - Makedonska Kamenica Mine the following can be concluded and used as important in reaching the right solutions, evaluations etc.:

- The projected two-stage grinding of lead-zinc mine ore with regard to the major goals of "unlocking" and "liberation" of mineral grains and their separation to valuable from useless grains by the creation of new surfaces does not yieled completely satisfactory results,

- the essential condition for the creation of the new surfaces are appropriate physico-mechanical characteristics of grinding bodies (hardness of grinding bodies - the rods and balls expressed in Rockwells and Brinels) and the technological characteristics of grinding bodies (resistance to wear, evenly constructed shapes and dimensions of grinding bodies and their stability etc.) which must be determined and unconditionally accepted.
- mill rods must be manufactured from alloyed steels by lamination and thermally treated to hardness up to the total average and length of the rod, not lower than 30-35 Rockwels or 280-330 Brtinels,
- mill balls should be made of alloyed steels by lamination and forging (seldom by casting) and thermally treated to hardness of the total average of the ball not lowler than 60 Rockvels or 650-700 Brinels,
- the reasons for the proposals put forward have been obtained by examinations of almost unsatisfactory average granulometric compositions at the discharge of the rod mill and that of ball mill in both technological phases of grinding, which is also confirmed by calculation for individual (specific) surfaces in the same mill aggregates,
- a new system of grinding should be planned for the ball mills (in both phases of secondary grinding) with transfer to "rational" supply and charging of mill balls in different ball ratio of different diameter, taking in consideration that the larger grinding surface creates greater specific surface of the ore ground, e.g. ratio of mill balls that are supplied in 25% φ80 mm and 75% φ60 mm ratios or similar,
- a specific feature during investigations is that efficiencies of classifying in spiral mechanical classifiers are not satisfactory. This is confirmed by the obtained average granulometric compositions in overflows of classifiers in both phases of grinding - classifying,
- During investigations there seems to be incomplete understanding of the processes grinding – classifying in the second phase where on average granulometric compositions coincide both at the discharge of the ball mill and the overflow of the spiral classifier. More precisely, the role of the classifier is not significant. Later on, it “is controlled” and “corrected” by the processing of the overflow obtained in the hydrocyclon.

CONCLUSION

Based on all mentioned above, the following solutions and technological variations can be put forward:

1. Filling of mechanical aggregates with appropriate mill bodies in accordance with ascribable physico-mechanical and technological characteristics,
2. Reconsideration of the use of mechanical spiral classifiers and hydrocyclons or improvement of their operating efficiency,
3. Considering the possibility of a new technological solution for primary grinding by the replacement of constructive characteristics of the mill and the use of the existing grinding media by mill balls of greater diameter and the use of combined semi-closed cycle in primary grinding,
4. Considering the possibility of application of optimal upper size limit of the crushed product in earlier crushing phase.

Capacity of the grinding mill: ***Increasing by using Forged Steel Balls about 12-15%***
Particle size: ***Improving about 10-12,3%***
Specific Energy: ***Decreasing about 5-5,3%***
Ball Consumption: ***Decreasing about 30-40% using Forged Steel Balls-L&N Balls***

REFERENCES

1. *Anon, Grinding mills-rod, ball and autogenous, Mining Magazine 197, 1982*
2. *Anon, Milling and grinding, Mine&Quarry, 15, 1986*
3. *Wills B.A., Mineral Processing Technology, 1988*
4. *Dodd J, Relative importance of abrasion and corosion in metal loss in ball milling, Minerals and Metallurgical Processing, 2, 212, 1985*
5. *Ramsey T.L, Reducing grinding costs: the potential is great, World Mining, 78, 1982*